FINAL REPORT

PROGRAM IN ACOUSTICS

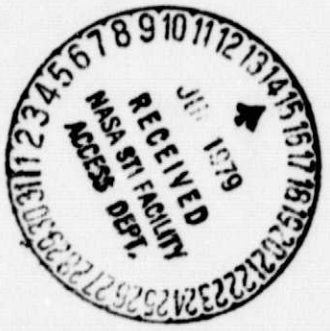
NGR 09-010-064

with

The George Washington University

at

The NASA-Langley Research Center



School of Engineering and Applied Science
The George Washington University
Washington, D. C. 20052

FINAL REPORT

September 1, 1970 - March 31, 1979

PROGRAM OF RESEARCH IN ACOUSTICS

NGR 09-010-064

CONTENTS

ABSTRACT

The objective of the Acoustics Research Program is to conduct relevant research at the NASA-Langley Research Center in the general area of Aeroacoustics while contributing to the education program at the Center leading to advanced degrees in Acoustics. The research is aimed at understanding noise generation from aircraft and in developing practical methods of noise suppression. The program, which was first initiated in January 1970, currently has one full-time faculty member and one research assistant. The accomplishments during the past years are discussed with particular emphasis on the period September 1977 - March 1979.

The Acoustics Program is an integral part of JIAFS major research projects, which are affiliated with the Department of Civil, Mechanical and Environmental Engineering.

1. OVERALL PROGRESS

The activities and accomplishments of the program from its inception in 1970 up through August 1977 have been discussed in detail in previous annual reports. The current report will summarize the earlier activity and present specific details of the activities in the program during the final period, September 1977 through March 1979.

The faculty and research assistants associated with the Acoustics Program have published their research findings in various technical journals and NASA publications. In addition, numerous presentations have been made at technical meetings throughout the country and overseas. A listing of these publications and presentations can be found in Appendix A along with a listing in Appendix B of all faculty members in the program and the dates of their involvement.

The Graduate Research Scholar Assistants who have been supported under the Acoustics Program are listed in Appendix C, and the dissertations and theses completed by these Assistants are given in Appendix D.

Finally, Appendix E contains a list of part-time students who have completed or are currently pursuing a degree program under the supervision of faculty members in the program.

Professor S. W. Yuan, Associate Director of the JIAFS Program, under the direction of Dean Harold Liebowitz, Principal Investigator of the Acoustics Program, has been responsible for recruiting research assistants, as well as for looking after the progress of the students' work. He also helped plan the budget and to develop, improve, and coordinate the program

with the engineering faculty at The George Washington University and with Southampton University's Institute for Sound and Vibration Research.

The program has been coordinated at NASA-Langley Research Center by Dr. J. L. Whitesides, Assistant Director, Research and Education, JIAFS.

For the period September 1977 through March 1979, the Acoustics Program has included the following persons:

Faculty Members:

Dean Harold Liebowitz, Principal Investigator

Dr. M. K. Myers, Professor

Dr. J. L. Whitesides, Associate Professor

Dr. S. W. Yuan, Professor

Graduate Research Scholar Assistants:

S. L. Chuang (M.S. University of Texas), August 1978 to present

N. R. Dixon (M.S. Southampton University), January 1977 to October 1978

G. L. McAninch (M.S. University of Illinois), September 1974 to May 1978

The Acoustics Program has been an integral part of the JIAFS major research programs, which are affiliated with the Department of Civil, Mechanical and Environmental Engineering under the Chairmanship of Dr. S. W. Yuan (1974-1978) and Dr. A. B. Cambel (1978-present).

2. RESEARCH PROGRESS: September 1, 1977 - March 31, 1979

Research activities of the faculty and graduate students in the Acoustics Program during the above period are summarized in this section.

Dr. M. K. Myers - Professor

The bulk of Dr. Myers' research time during the period September 1977 through March 1979, has been devoted to two projects. The first of these is

the study of acoustic wave propagation in near-sonic duct flows in which nonlinear effects on sound become the dominant physical effect. The basic theory governing the nonlinear acoustic waves was formulated during earlier phases of the project, and most of the effort during the current period has been directed towards applying the theory to several cases of practical interest. The early theoretical results and their application to the case of an acoustic source located at the throat of a near-sonic duct were reported at the AIAA 4th Aeroacoustics Conference in October, 1977.

During the period October, 1977 through May, 1978, a computer program was written which carries out detailed numerical computations of the nonlinear theory when the acoustic source is located at the near-sonic throat and is of low enough strength that no shock waves are developed in the sound field. The numerical results are most conveniently given in terms of acoustic energy flux in the duct, a quantity which, for the quasi-one-dimensional theory being used, has not been defined consistently in the literature. Thus, during the same period, a theoretical study was undertaken which resulted in a proper definition of energy flux in the case of interest. Use of this flux expression allows the nonlinear interactions between the mean flow and the sound field to be interpreted in the context of energy transfer from the mean flow into the acoustic field. The numerical results obtained with the program were summarized in two papers during the summer of 1978 (see #52 and #53, Appendix A).

During the final months of the current period, efforts were concentrated on extending the theory and developing a computer program to handle

the significantly more complicated problem of propagation through a near-sonic throat from a source located outside the throat region of the duct. This work was completed in early February, 1979, and the numerical results obtained were reported in a paper at the AIAA 5th Aeroacoustics Conference in March, 1979.

The second project carried out by Dr. Myers is the development and application of a parabolic approximation theory for propagation of sound in moving stratified media. A restricted version of this theory was reported in a paper by Myers and McAninch which appeared in the AIAA Journal in August, 1978. Efforts during the period since January, 1978, have been directed towards generalizing the theory to account for fully three-dimensional wave propagation and towards application of the theory to several problems of practical interest in connection with sound propagation in the atmosphere. A fairly general numerical scheme for solving the propagation equations was developed by Mr. G. McAninch as part of his doctoral research under Dr. Myers' supervision.

In addition to the above work, Dr. Myers also participated in revising the M.S. thesis of Mr. W. B. McDonald, which was published as a NASA Technical Paper in May, 1978. Further, he taught courses in the graduate educational program during the subject period, acted as MS thesis advisor for several NASA students, and participated on editorial boards for several NASA publications.

Graduate Research Assistants

S. L. Chuang - Mr. Chuang joined the program in August, 1978 as a doctoral student working under the supervision of Professor Myers. His research work

during the early stage has been confined to assisting Dr. Myers in the development of the computer programs for the near-sonic duct work.

N. R. Dixon - Mr. Dixon completed the requirements for the Professional Degree in October, 1978, and accepted a position at Bolt, Beranek, and Newman, Inc. His research work was supervised by Dr. J. C. Yu of NASA and was concerned with an experimental study of sound radiated from a subsonic jet in simulated forward motion. Some of the results of this project were reported in a paper at the AIAA 17th Aerospace Sciences Meeting in January, 1979, and a more complete discussion of the project appears as the Project Report for the Degree of Engineer which Mr. Dixon successfully defended in April, 1979.

G. L. McAninch - Mr. McAninch was supported on an assistantship up through May, 1978, when he accepted a position at the General Electric Company. His research for the doctoral degree was on the application of the parabolic approximation for atmospheric sound propagation, under the supervision of Professor Myers. All of the analytical and computational work for his dissertation has been completed, and he is in the final stages of rewriting the dissertation in preparation for its defense in the near future.

APPENDIX A

PUBLICATIONS AND PRESENTATIONS

1. S. E. Wright, "Discrete Radiation from Rotating Periodic Sources," published Journal of Sound & Vib., Vol. 17, No. 4, 1971, pp. 437-498.

2. S. E. Wright, "Discrete Rotor Noise," presented American Helicopter Society, Durham, NC, September 28-30, 1971 and 1971 Conference on Noise Control, Purdue University, W. Lafayette, IN, July 14-16, 1971.

3. S. E. Wright, "A Unique Program of Research and Education in Noise Acoustics," presented 81st Meeting of the Acoustical Soc. of America, Washington, DC, April 20-23, 1971.

4. B. L. Clarkson, "Estimates of the Response of Box Type Structures to Acoustic Loading," presented AGARD Symposium on Acoustic Fatigue, Toulouse, France, September 26-27, 1972.

5. B. L. Clarkson and I. Ashie, "Computer Based Analysis of the Response of Box Type Structures to Random Pressures," presented National Symposium on Computerized Structural Analysis and Design, The George Washington University, Washington, DC, March 27-29, 1972.

6. M. Budoff and W. Zorumski, "Flow Resistance of Perforated Plates in Tangential Flow," published NASA TM X-2361, October 1971.

7. D. S. Dosanjh; J. C. Yu; and A. N. Abdelhamid, "Reduction of Noise from Supersonic Jet Flows," published AIAA Journal, Vol. 9, No. 12, December 1971, pp. 2346-2353.

8. J. C. Yu, "Far Noise Field of a Subsonic Air Jet," presented 84th Meeting of the Acoustical Society of America, Miami Beach, FL, November 28-December 1, 1972.

9. J. C. Yu, "Noise Field of a Supersonic Mach 1.5 Cold Model Jet," published Journal of Acoustical Society of America, Vol. 51, No. 5, Part 1, May 1972, pp. 1400-1410.

10. D. S. Dosanjh and J. C. Yu, "Reply by Authors to Comments on 'Reduction of Noise from Supersonic Jet Flows'," published AIAA Journal, Vol. 11, No. 3, March 1973, pp. 415-416.

11. N. N. Reddy and J. C. Yu, "Experimental Investigation of Radiated Acoustic Power of an Externally Blown Flap," presented 85th ASA Meeting, Boston, MA, April 1973.

12. J. C. Yu and P. Mungur, "Acoustic Wave Propagation in an Axisymmetric Swirling Jet," presented AIAA Aeroacoustics Specialist Meeting, Seattle, WA, October 1973, Paper No. 73-1004. Published AIAA Progress Series in Astronautics and Aeronautics, Vol. 37, Jet and Combustion Noise, Duct Acoustics, 1974.

13. A. Kapur and P. Mungur, "Sound Interaction with a Helical Flow Contained in an Annular Duct with Radial Gradients of Flow, Density, and Temperature," presented AIAA Aeroacoustics Specialist Meeting, Seattle, WA, October 1973, Paper No. 73-1010. Published AIAA Progress Series in Astronautics and Aeronautics, Vol. 37, Jet and Combustion Noise, Duct Acoustics, 1974.

14. J. L. Whitesides and P. Mungur, "On the Influence of Temperature Gradients in Jet Flows on the Radiation of Sound," presented 86th ASA Meeting, Los Angeles, CA, November 1973.

15. C. Kouts and J. C. Yu, "Far Noise Field of a Two-Dimensional Subsonic Jet," presented AIAA 12th Aerospace Sciences Meeting, Washington, DC, January 1974, AIAA Paper No. 74-44.

16. M. K. Myers and G. I. Zahalak, "On the Accuracy of Whitham's Method," published AIAA Journal, Vol. 12, No. 2, pp. 203-207, February 1974.

17. P. Mungur and A. Kapur, "Theoretical Evaluation of Sound Fields in Circular or Annular Ducts with Rigid or Non-Rigid Radial Splitters," presented 87th ASA Meeting, New York, NY, April 1974.

18. A. Ozkul, "Investigation of Acoustic Radiation from Supersonic Turbulent Jets by Double-Pulse Holographic Interferometry," presented 87th ASA Meeting, New York, NY, April 1974.

19. R. N. Hosier and R. Ramakrishnan, "Helicopter Rotor Rotational Noise Prediction Based on Measured High-Frequency Blade Loads," published NASA TN D-7624, December 1974.

20. R. N. Hosier; R. Ramakrishnan; and R. J. Pegg, "The Prediction of Rotor Rotational Noise Using Measured Fluctuating Blade Loads," presented 30th Annual Helicopter Society, Washington, DC, May 1974.

21. J. C. Yu; N. N. Reddy; and J. L. Whitesides, "Noise and Flow Characteristics of an Externally Blown Flap," published Proceedings of the 2nd Interagency Symposium on University Research in Transportation Noise, Vol. I, pp. 219-237, Raleigh, NC, June 1974.

22. P. Mungur; J. C. Yu; J. L. Whitesides; and W. R. Arnold, "Some Theoretical Studies on Noise Propagation, Attenuation and Radiation in Turbo-Fan Engine Environments," published Proceedings of 2nd Interagency Symposium on University Research in Transportation Noise, Vol. II, pp. 888-901, Raleigh, NC, June 1974.

23. R. Ramakrishnan; D. Randall; and R. Hosier, "A Computer Program to Predict Rotor Rotational Noise," published NASA TM X-3281, February 1976.

24. P. Mungur; J. C. Yu; and J. L. Whitesides, "A Theoretical Evaluation of the Acoustic Response of a Free Turbulent Jet and Some Aspects of Relative Amplification and Frequency Selection," presented 8th International Congress on Acoustics, London, 1974, Paper No. 153. Published Proceedings of the 8th ICA, Vol. II, p. 530, 1974.

25. J. C. Yu and N. N. Reddy, "Noise and Flow Characteristics of a Subsonic Jet Impinging on a Finite Rigid Plate," presented 8th International Congress on Acoustics, London, July 1974. Published Proceedings of the 8th ICA, Vol. II, p. 547, 1974.

26. J. L. Whitesides and P. Mungur, "The Effect of Jet Temperature Gradients on the Directivity of Sound Radiation," presented 8th International Congress on Acoustics, London, July 1974, Paper No. 161. Published Proceedings of the 8th ICA, Vol. II, p. 486, 1974.

27. A. Kapur and P. Mungur, "A Theoretical Formulation of the Influence of a Boundary Layer Growth in an Inlet Flow Duct with Temperature Gradients on Sound Distribution," presented 8th International Congress on Acoustics, London, July 1974, Paper No. 633. Published Proceedings of the 8th ICA, Vol. II, p. 489, 1974.

28. P. Mungur; H. E. Plumblee; and P. E. Doak, "Acoustic Radiation Analysis in Jet Flow Environment," published Journal of Sound & Vib., 1974 (36)1, pp. 21-52.

29. N. N. Reddy, and J. C. Yu, "Noise Radiation from an Externally Blown Flap," published NASA TN D-7908, 1975.

30. P. Mungur and J. L. Whitesides, "Influence of Grazing Flow on Duct Wall Normal Impedances," presented AIAA 2nd Aeroacoustics Conference, March 1975, Hampton, VA, AIAA Paper No. 75-494.

31. M. K. Myers and P. Mungur, "Sound Propagation in Curved Ducts," presented AIAA 2nd Aeroacoustics Conference, March 1975, Hampton, VA, AIAA Paper No. 75-497.

32. C. K. W. Tam and J. C. Yu, "Trailing Edge Noise," presented AIAA 2nd Aeroacoustics Conference, March 1975, Hampton, VA, AIAA Paper No. 75-489.

33. J. C. Yu; C. D. Smith; and P. Mungur, "Acoustic Wave Propagation in a Lined Duct with Non-Uniform Admittance," presented AIAA 2nd Aeroacoustics Conference, March 1975, Hampton, VA, AIAA Paper No. 75-515.

34. W. R. Arnold, "Sparse Matrix Techniques Applied to Modal Analysis of Multi-Section Duct Liners," presented AIAA 2nd Aeroacoustics Conference, March 1975, Hampton, VA, AIAA Paper No. 75-714.

35. A. Kapur and P. Mungur, "Duct Acoustics and Acoustic Finite Element," presented AIAA 2nd Aeroacoustics Conference, March 1975, Hampton, VA, AIAA Paper No. 75-498.

36. C. A. Kouts and J. C. Yu, "Far Noise Field of a Two-Dimensional Subsonic Jet," published AIAA Journal, Vol. 13, No. 8, August 1975, pp. 1031-1035.

37. M. K. Myers and P. Mungur, "Sound Propagation in Curved Ducts," presented Third Interagency Symposium on University Research in Transportation Noise, US Dept. of Transportation, Salt Lake City, UT, November 12-14, 1975. Published Proceedings of the Symposium.

38. J. C. Yu; C. D. Smith; and P. Mungur, "Acoustic Wave Propagation in a Lined Duct with Non-Uniform Admittance," presented Third Interagency Symposium on University Research in Transportation Noise, US Department of Transportation, Salt Lake City, UT, November 1975. Published Proceedings of the Symposium.

39. N. N. Reddy and J. C. Yu, "Noise from Turbulent Jet Flow Over Wing/Flap Surfaces," presented AIAA 3rd Aeroacoustics Conference, July 1976, Palo Alto, CA, AIAA Paper 76-522.

40. A. J. Callegari and M. K. Myers, "Effects of High Subsonic Flow on Sound Propagation in a Variable-Area Duct," presented 13th Annual Meeting of the Society of Engineering Science, Hampton, VA, November 1-3, 1976. Published Proceedings of the Meeting.

41. L. K. Barker and J. L. Whitesides, "Stability of Neutral Equations with Constant Time Delays," presented 13th Annual Meeting of the Society of Engineering Science, Hampton, VA, November 1-3, 1976. Published Proceedings of the Meeting.

42. P. Mungur and J. L. Whitesides, "Influence of Grazing Flow on Duct Wall Normal Impedances," published Progress in Astronautics and Aeronautics, Vol. 44, p. 289, 1976.

43. M. K. Myers and P. Mungur, "Sound Propagation in Curved Ducts," published Progress in Astronautics and Aeronautics, Vol. 44, p. 347, 1976.

44. C. K. W. Tam and J. C. Yu, "Trailing Edge Noise," published Progress in Astronautics and Aeronautics, Vol. 45, p. 259, 1976.

45. J. C. Yu; C. D. Smith; and P. Mungur, "Acoustic Wave Propagation in a Lined Duct with Non-Uniform Admittance," published Progress in Astronautics and Aeronautics, Vol. 44, p. 397, 1976.

46. L. R. Clark and J. C. Yu, "Effects of Geometry and Jet Velocity on Noise Associated with an Upper-Surface Blowing Model," published NASA TN D-3836, March 1977.

47. M. K. Myers and A. J. Callegari, "On the Singular Behavior of Linear Acoustic Theory in Near-Sonic Duct Flows," published Journal of Sound & Vib., Vol. 51, No. 4, April 1977.

48. J. C. Yu, "An Experimental Investigation of Trailing Edge Noise Mechanism," published AIAA 4th Aeroacoustics Conference, October 3-5, 1977, Paper No. 77-1291.

49. A. J. Callegari and M. K. Myers, "Nonlinear Effects on Sound in Nearly Sonic Duct Flows," published AIAA 4th Aeroacoustics Conference, October 3-5, 1977, Paper No. 77-1296.

50. M. K. Myers and G. L. McAninch, "The Parabolic Approximation for Sound Propagation in a Stratified Moving Medium," published AIAA 4th Aeroacoustics Conference, October 3-5, 1977, Paper No. 77-1310.

51. W. B. McDonald; R. Vaicaitis; and M. K. Myers, "Noise Transmission Through Plates Into an Enclosure," published NASA TP 1173, May 1978.

52. M. K. Myers and A. J. Callegari, "Nonlinear Theory of Sound Transmission in a High Subsonic Flow," presented 8th US National Congress of Applied Mechanics, June 26-30, 1978.

53. M. K. Myers and A. J. Callegari, "Transmission of Sound Through High Subsonic Flows in Non-Uniform Ducts," published AIAA Paper No. 78-115. Presented AIAA 11th Fluid and Plasma Dynamics Conference, July 10-12, 1978.

54. M. K. Myers and G. L. McAninch, "Parabolic Approximation for Sound Propagation in the Atmosphere," published AIAA Journal, Vol. 16, No. 8, August 1978, pp. 836-842.

55. A. Ozkul and J. C. Yu, "An Experimental Investigation of Acoustic Radiation from a Source Inside a Large Turbulent Free Jet," published Journal of Acoustical Society of America 65(2), February 1979, pp. 336-344.

56. A. J. Callegari and M. K. Myers, "Sound Transmission in Ducts Containing Nearly Choked Flows," presented AIAA 5th Aeroacoustics Conference, Seattle, WA, March 12-14, 1979. Published AIAA Paper No. 79-0623.

57. N. R. Dixon and J. C. Yu, "An Experimental Study of Sound Radiation from a Subsonic Jet in Simulated Motion," presented 17th Aerospace Sciences Meeting, January 15-17, 1979, New Orleans, LA. Published AIAA Paper No. 79-0185.

APPENDIX B

FACULTY MEMBERS

ACOUSTICS PROGRAM

Full-time

Dr. Selwyn E. Wright, January 1970 - July 1971

Dr. James C. Yu, June 1971 - June 1977

Dr. Gary Koopmann, September 1971 - December 1971

Professor Christopher G. Rice, January 1972 - June 1972

Dr. Maurice Petyt, July 1972 - January 1973

Dr. George F. Kuhn, September 1972 - March 1973

Dr. Parmanand Mungur, January 1973 - June 1975

Dr. Michael J. Griffin, March 1973 - August 1973

Dr. Michael K. Myers, July 1973 - present

Part-time

Professor S. W. Yuan, 1970 - present

Dr. J. L. Whitesides, 1970 - present

APPENDIX C

GRADUATE RESEARCH SCHOLAR ASSISTANTS

ACOUSTICS PROGRAM

Fall 1970

Raymond G. Holm, July 1970 - June 1972, graduated Summer 1972
Ibrahim A. Ashie, September 1970 - August 1972, graduated Summer 1972
Marvin A. Budoff, September 1970 - August 1972, graduated Spring 1973
Ernesto A. Gonzaga, September 1970 - August 1972, graduated Summer 1972

Fall 1971

Christopher A. Kouts, August 1971 - July 1973, graduated Fall 1974
Ramani Ramakrishnan, September 1971 - August 1973, graduated Summer 1973

Spring 1972

Sheldon A. Bloom, January 1972, resigned March 1974
Mary V. Jones, January 1972, resigned July 1972

Fall 1972

William T. Hardrath, June 1972, resigned June 1973
William R. Arnold, September 1972 - April 1975, graduated Spring 1975
Ahmet Ozkul, September 1972 - August 1974, graduated Fall 1974
Ljubomir J. Liebich, September 1972 - April 1975, graduated Spring 1975

Spring 1973

Wilson A. Thorpe, January 1973 - June 1974

Fall 1973

Ramani Ramakrishnan, August 1973 - November 1976, graduated Spring 1977 - DSc
Arthur L. Strenkert, September 1973, resigned June 1974
Arnold Adams, September 1973, resigned March 1974

Fall 1974

Charles D. Smith, June 1974 - July 1976
James E. Garber, July 1974 - May 1975
Patrick G. Sullivan, August 1974 - December 1975, graduated Spring 1976
Ahmet Ozkul, September 1974 - July 1977, graduated Summer 1977 - Professional
Gerry L. McAninch, September 1974 - May 1978
Bennett M. Brooks, September 1974 - August 1976, graduated Summer 1977

Fall 1975

Jonathan R. Prescott, July 1975 - June 1977
Wayne B. McDonald, September 1975 - August 1977, graduated Summer 1977

Spring 1977

Nicholas R. Dixon, January 1977 - October 1978, graduated Spring 1979 - Professional

Fall 1978

S. L. Chuang, August 1978 - present

APPENDIX D

DISSERTATIONS AND THESES

1. "Response of a Box Type Structure to Acoustic Loading," I. A. Ashie, MS Thesis, February 1973.

2. "Measurement of Acoustic Impedance of Typical Duct Lining Materials Subjected to Tangential Air Flow," M. A. Budoff, MS Thesis, March 1973.

3. "On the Design of Pressure Gradient Condenser Microphone," E. A. Gonzaga, MS Thesis, January 1973.

4. "On the Aerodynamic Noise Generation by Axial-Flow Compressors," R. G. Holm, MS Thesis, September 1972.

5. "An Experimental Investigation on the Noise Field Characteristics of a High Aspect Ratio, Cold, Subsonic, Model Slot Jet," C. A. Kouts, MS Thesis, September 1973.

6. "On Discrete Noise Radiation from Helicopters," R. Ramakrishnan, MS Thesis, September 1973.

7. "Investigation of Acoustic Radiation from Supersonic Turbulent Jets by Double-Pulse Holographic Interferometry," A. Ozkul, MS Thesis, June 1974.

8. "Acoustic Propagation Through a Wall-Jet Flow with Compliant Plates," R. Ramakrishnan, DSc Dissertation, May 1977.

9. "Scattering of an Acoustic Dipole by an Infinite Cylinder with Application to the Prediction of Airframe Noise," B. M. Brooks, MS Thesis, June 1977.

10. "An Experimental Investigation of Acoustic Radiation from a Source Inside a Large Turbulent Free Jet," A. Ozkul, Professional Engineer, June 1977.

11. "Noise Transmission Through Elastic Plates Into a Rectangular Enclosure," W. B. McDonald, MS Thesis, August 1977.

12. "An Experimental Investigation of Sound Radiation From a Subsonic Jet in Simulated Motion," N. R. Dixon, Professional Engineer, May 1979.

APPENDIX E

PART-TIME STUDENTS

ACOUSTICS PROGRAM

GRADUATED

Robert Grandle - Summer 1972 (MS)

Tony L. Parrott - Summer 1973 (MS)

Lorenzo R. Clark - Spring 1974 (MS)

C. A. Powell - Spring 1978 (DSc)

Willie Watson - Spring 1978 (MS)

Nettie Faulcon - Summer 1978 (MS)

Danny R. Hoad - Spring 1979 (MS)

CURRENTLY ENROLLED IN DEGREE PROGRAM

Patricia Block - DSc

Willie Watson - DSc

Richard Silcox - Professional

David McCurdy - MS